GEOMORPHIC INVESTIGATIONS AT CONTAMINATED SITES

INSIGHTS FROM GEOMORPHOLOGY

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TOPICS TO BE PRESENTED

- Long-term stability of contaminated sediments
- Fundamentals of engineering geomorphology
- Geomorphology in managing contaminated sediments
- Framework for geomorphological investigations of contaminated sediment

Geomorphological Investigations of Contaminated Sediment

Goal

Provide program managers, scientists, and engineers with a comprehensive analysis of historic, present, and future geomorphologic and sedimentary conditions and processes that control or influence the location, movement, and burial of contaminated sediments

KEY QUESTIONS: CONTAMINATED SEDIMENTS

- Where do contaminated sediments occur?
- What are the geometries of contaminated sediment bodies?
- What are the processes controlling long-term stability?
- How do the magnitude, frequency, and duration of sediment processes vary in time and space?
- What is the average sedimentation rate of the river?

GEOMORPHOLOGY: DEFINITIONS

Geomorphology: The study and analysis of landforms and landscapes, the processes and factors that form them, and their evolution in time and space.

Engineering Geomorphology: The application of the science of geomorphology to the planning, design, construction, and/or operation of engineering projects.

A GEOMORPHIC EQUATION

$$L = f(P, M) \Delta T, \Delta S$$

Where:

L = Landform (sediment body)

P = Processes

M = Material

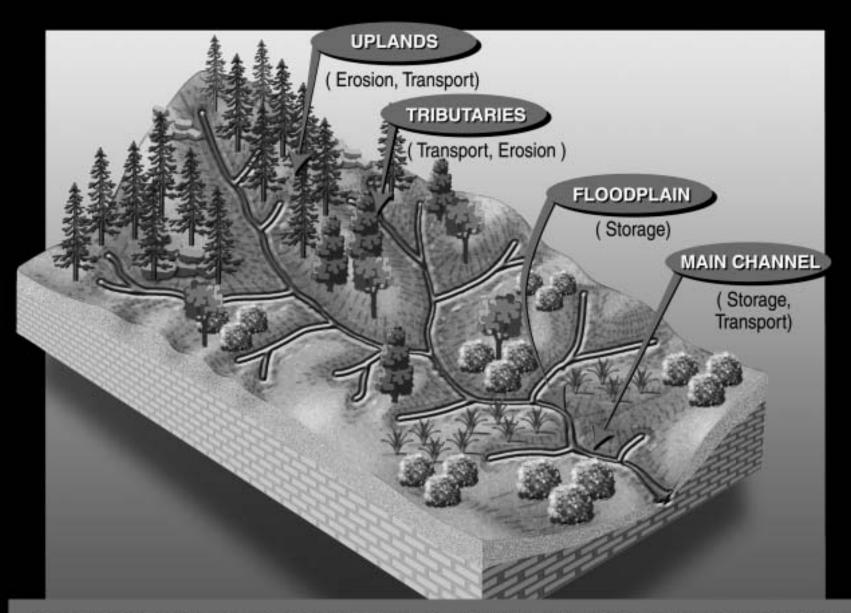
T = Time

S = Space

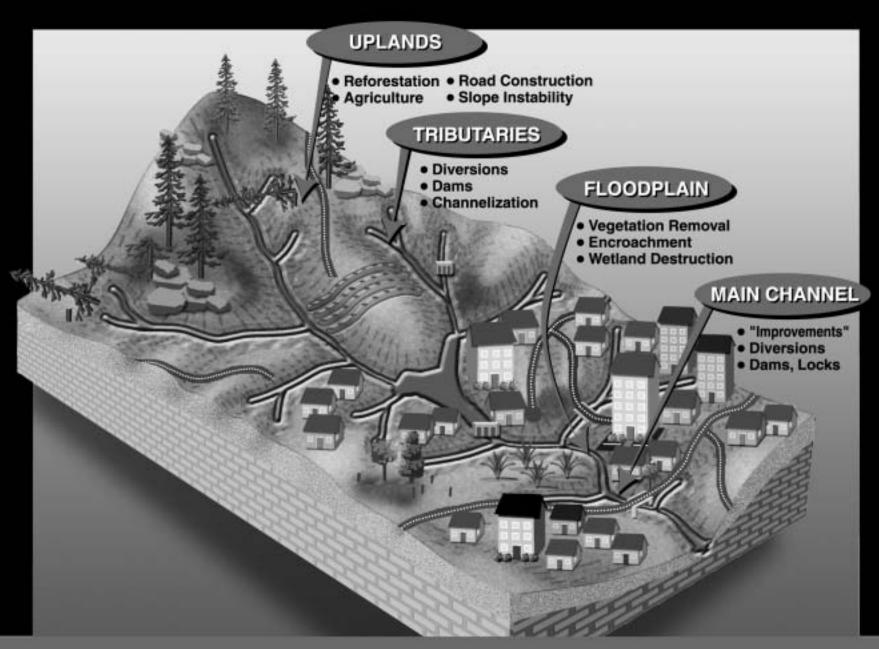
GEOMORPHOLOGICAL CONCEPTS: SEDIMENT STABILTY

Geomorphological systems, elements, processes, and uniformity

- Elements-typical surface and subsurface conditions
- Geomorphic process-landform/sediment products
- Uniformity and environmental change

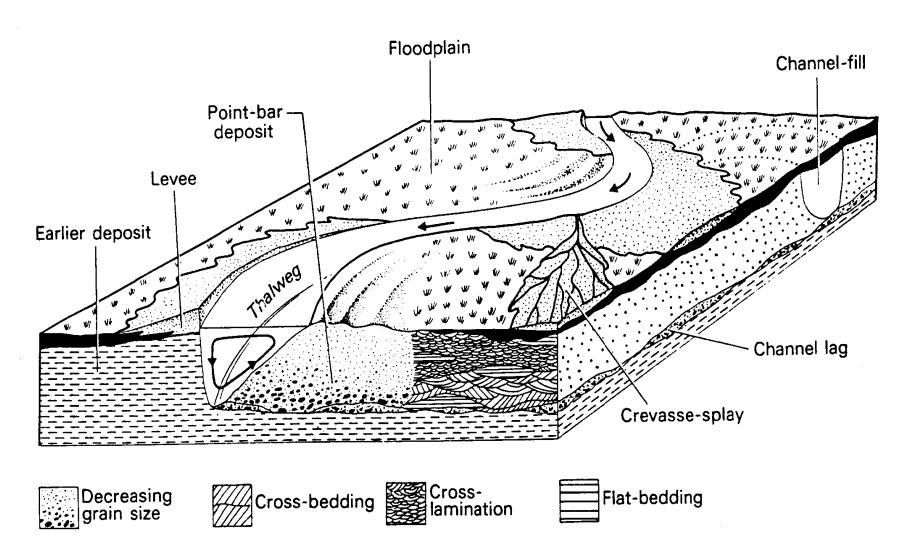


PRIMARY COMPONENTS OF A FLUVIAL GEOMORPHIC SYSTEM

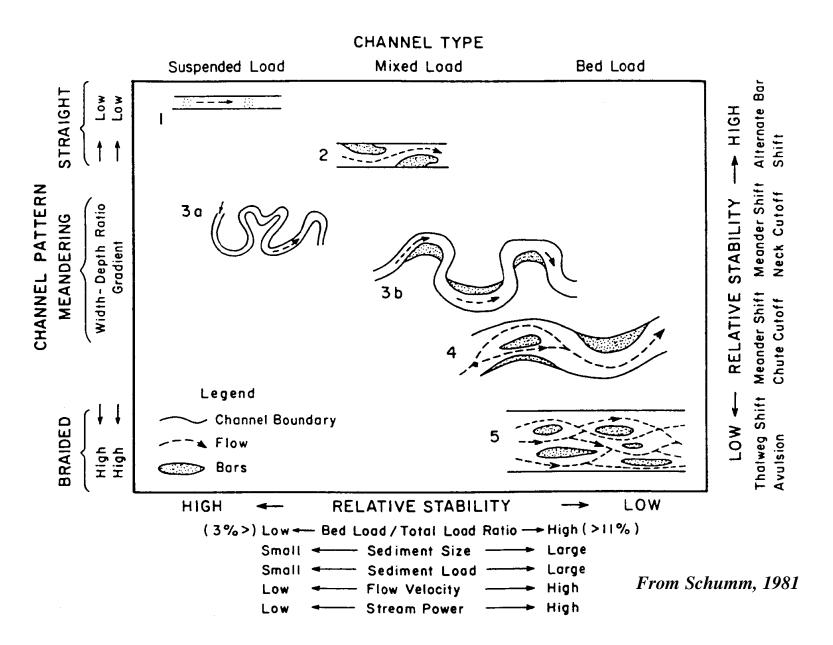


HISTORIC IMPACTS ON FLUVIAL GEOMORPHIC SYSTEMS

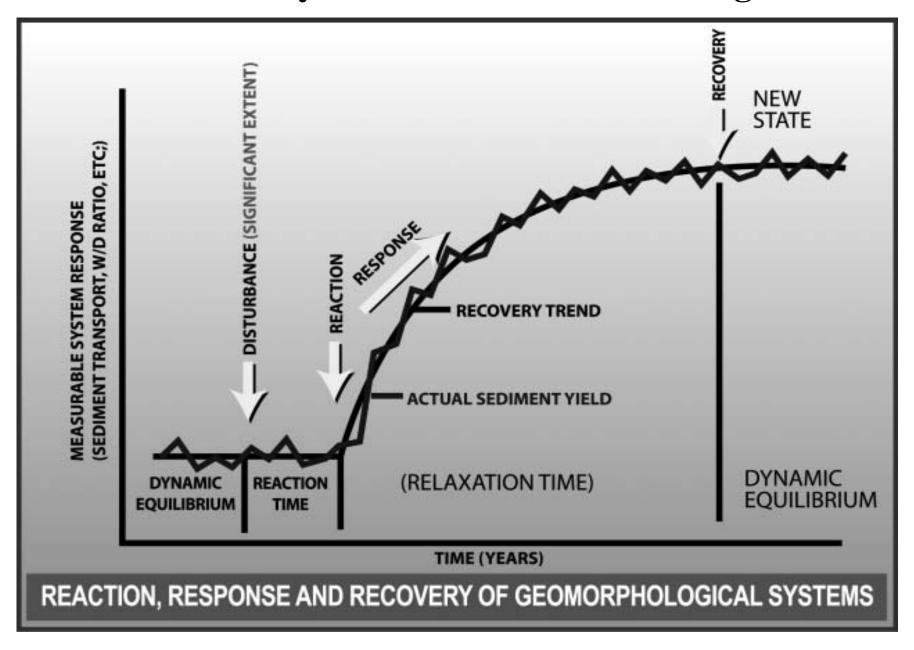
Landforms-Typical Surface and Subsurface Conditions

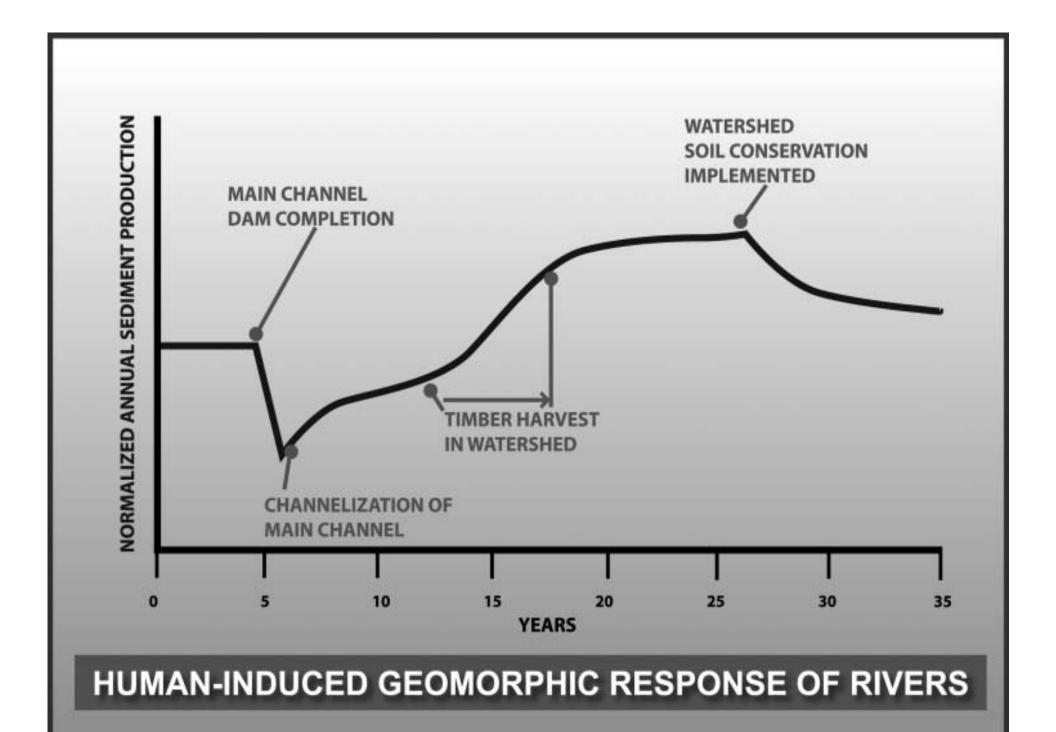


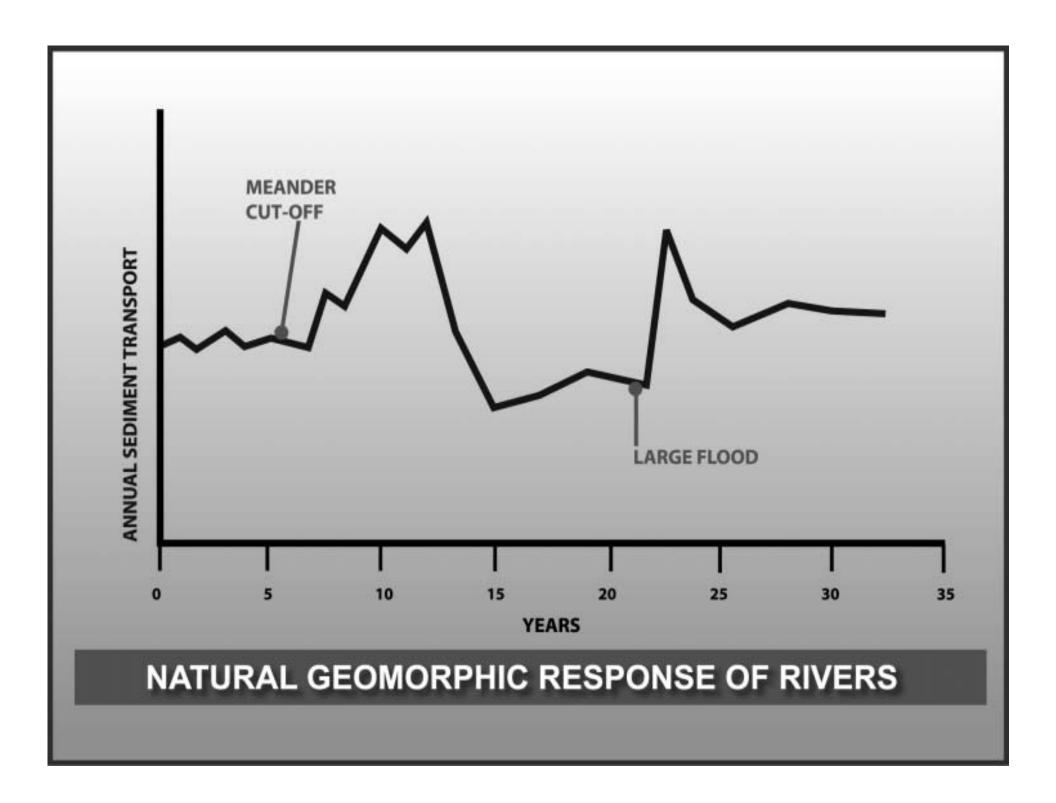
Geomorphic Process-Landform/Sediment Products



Uniformity and Environmental Change





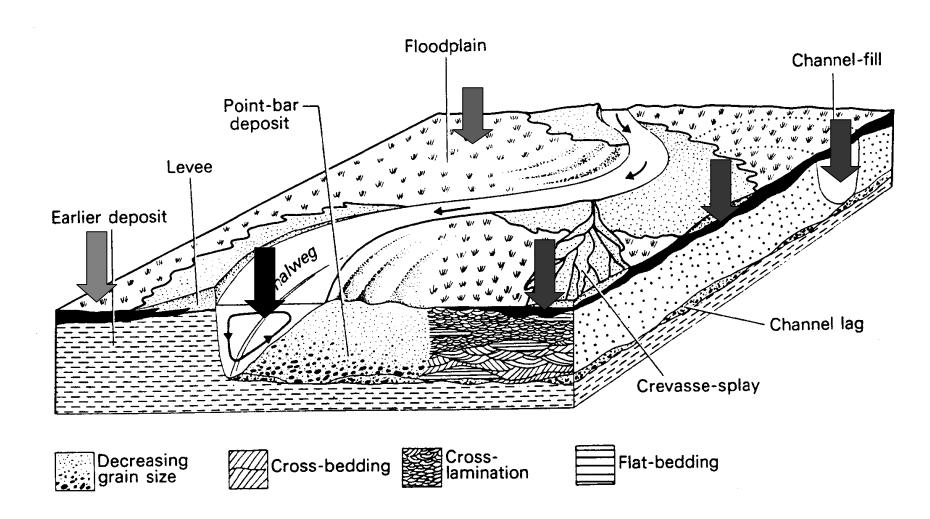


ENGINEERING GEOMORPHOLOGY

IMPORTANCE TO CONTAMINATED SEDIMENT MANAGEMENT

Where do contaminated sediments occur at or near the surface?

Locations of Contaminated Sediments



Where do contaminated sediments occur at or near the surface?

Concept: Landforms-typical surface and subsurface conditions.

Data: Historic maps, aerial imagery, topographic maps, streamflow data, subsurface sampling, analysis and testing of samples.

Products: Maps of contaminated sediment occurrence, explanation of historic deposition of contaminated sediments

What are the magnitude, frequency, and duration of processes controlling the long-term stability of contaminated sediments?

Geomorphological Processes Influencing the Stability of Contaminated Sediments

PROCESS	IMPACT	ENVIRONMENT
Erosion	De-stabilizing	Water column
Transport	De-stabilizing	Water column
Deposition	Stabilizing	Water column
Bioturbation	De-stabilizing	Substrate
Dessication/hyd.	Both	Ground surface
Freeze/thaw	Both	Ground surface
Biogeochemical	Both	Substrate
Consolidation	Stabilizing	Subsurface

Continued

Geomorphological Processes Influencing the Stability of Contaminated Sediments

PROCESS	IMPACT	ENVIRONMENT
Settlement	Both	Subsurface
Collapse	De-stabilizing	Subsurface
Compaction	Stabilizing	Subsurface
Cementation	Stabilizing	Subsurface
Disentegration	De-stabilizing	Ground surface
Decomposition	Both	Ground surface
Dispersion, piping	De-stabilizing	Subsurface
Liquifaction	De-stabilizing	Subsurface

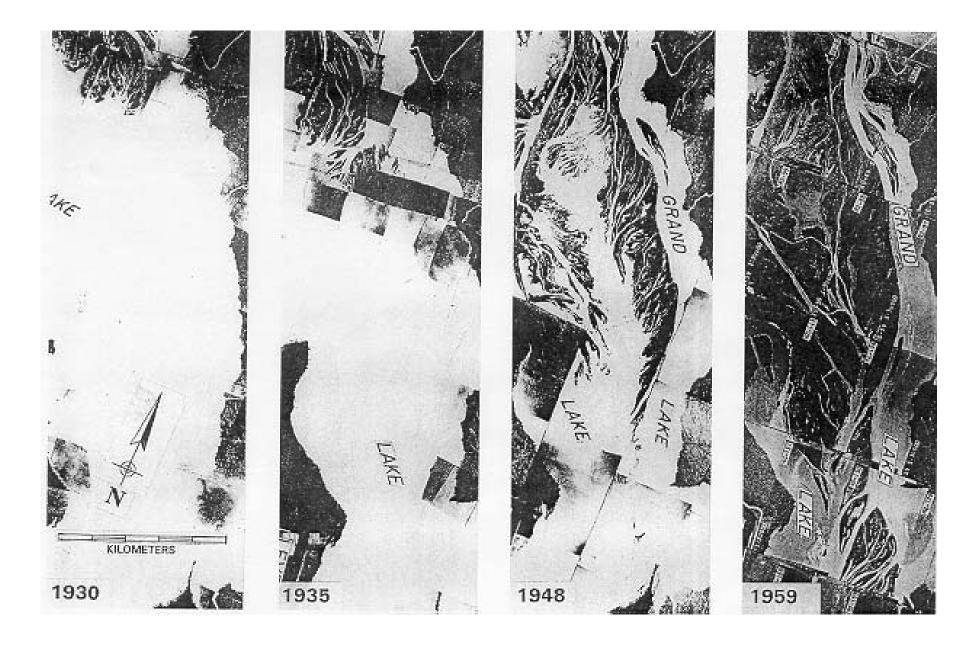
What are the magnitude, frequency, and duration of processes controlling the long-term stability of contaminated sediments?

Concepts: Geomorphological systems, elements, processes, and linkages

Data: Historic topographic maps, hydrographic charts, and aerial photographs; meterological, sedimentological, geochemical and soil physics data

Products: Graphical and numerical descriptions and analyses of the processes that cause and/or influence sediment instability.

Historic Filling of Grand Lake, Louisiana



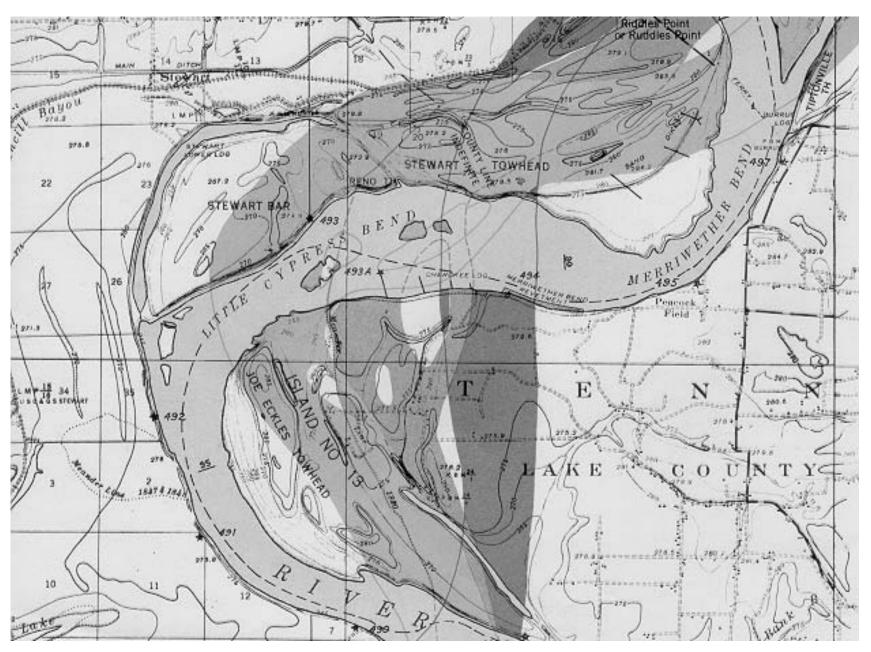
How do the magnitude, frequency, and duration of contaminated sediment processes vary in time and space?

Concepts: Geomorphic process – landform relationships

Data: Historic topographic maps, hydrographic charts, and aerial photographs; meterological, sedimentological, biogeochemical and soil physics data; sediment age dating; biogeochemical data.

Products: Maps, diagrams, and other graphical portrayals of the distribution of processes influencing sediment instability as a function of space and time.

Historical Changes of the Mississippi River

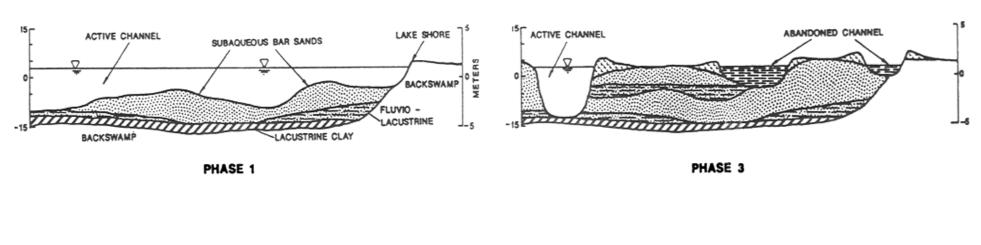


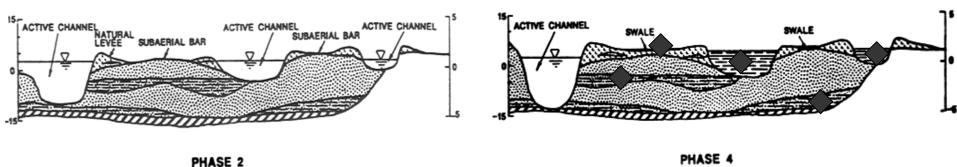


Lower Ohio River: A relatively stable channel system

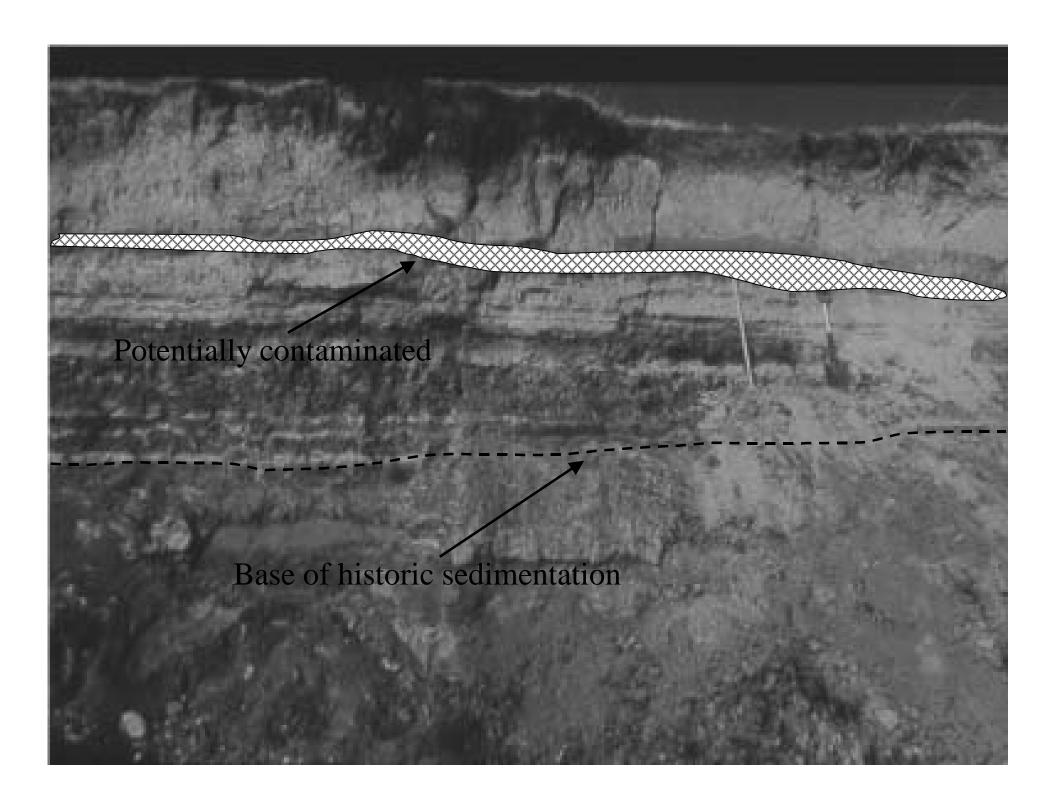
What is the probability that contaminated sediments will be buried by clean sediments or exposed to re-mobilization?

Historical Development of Deltaic Lobes Grand Lake Louisiana





Potential locations of Contaminated sediment



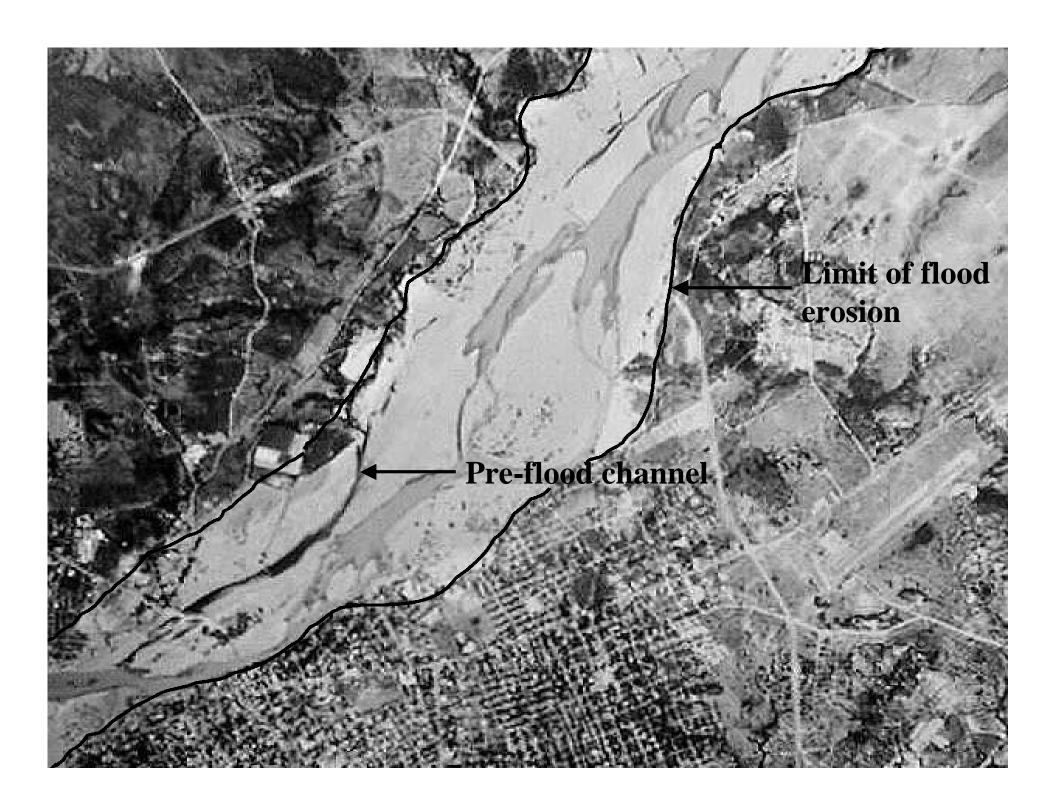
What is the probability that contaminated sediments will be buried by clean sediments or exposed to re-mobilization?

Concepts: Geomorphological systems structure, components, linkages, and dynamics.

Data: Streamflows, sediment transport, hydrographic surveys, waterborne geophysical data, topographic maps, aerial photographs, laboratory analyses of sediment samples.

Products: Sediment budget for areas of concern, including specific locations; Predictions of sediment movement at specific locations.

What will be the impact of large storms and other significant events on contaminated sediments?





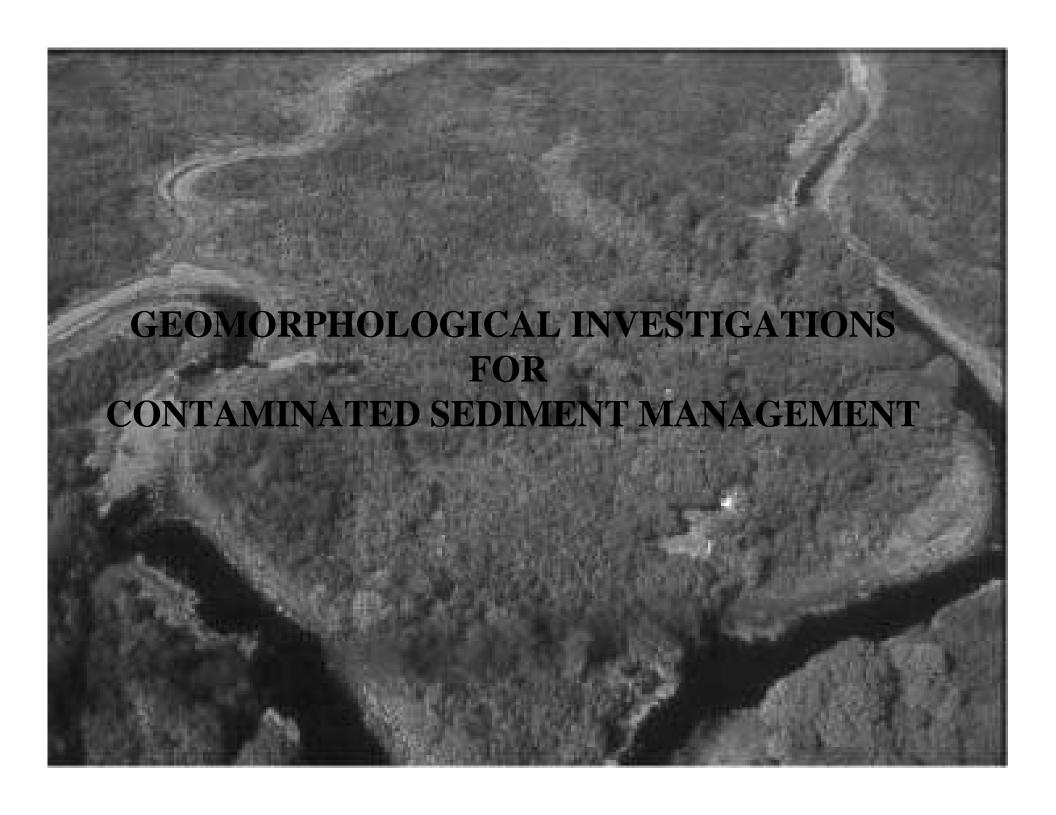
Minimally Impacted Stream System

What will be the impact of large storms and other significant events on contaminated sediments?

Concept: Uniformity and environmental change.

Data: Streamflows, sediment transport, hydrographic surveys, waterborne geophysical data, topographic maps, aerial photographs, laboratory analyses of sediment samples.

Product: Predictions of the impacts of large flow events on sediment stability and location.



GEOMORPHOLOGICAL INVESTIGATION ACTIVITIES

- *Identification and delineation* of features, conditions, and processes
- *Measurement and description* of features, conditions, and processes
- Analysis of processes, factors, and systems
- *Testing* of hypotheses and analysis of *uncertainty*

Continued

GEOMORPHOLOGICAL INVESTIGATION ACTIVITIES

- **Reconstruction** of past conditions and processes
- *Explanation* of the impact of geomorphic processes upon the project
- *Prediction* of future conditions and processes
- *Prescription* of conceptual solutions to meet project goals

Concluded

GEOMORPHOLOGICAL INVESTIGATION METHODS

- Field investigations
- Interpretation and analysis of imagery
- Geographic information systems
- Laboratory testing, analysis, and modeling
- Development of conceptual models
- Development of numerical models
- Evaluation of engineering designs and actions

MESSAGE

Contaminated sediment management requires a comprehensive and systematic understanding of the processes and conditions that were responsible for their transport, deposition, burial, and re-exposure.

Detailed geomorphological investigations will provide an invaluable foundation to the development of scientifically based management strategies.

